

1. A student wearing shoes stands on a tile floor. The student's shoes do not fall into the tile floor due to:

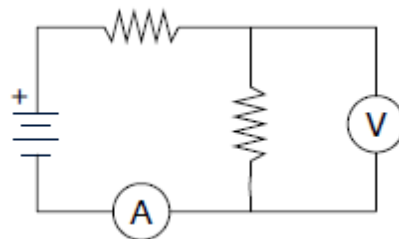
- (A) a force of repulsion between the shoes and the floor due to macroscopic gravitational forces.
- (B) the electrical repulsion between the shoes and the floor due to interatomic electric forces.
- (C) the strong nuclear force creating a force of repulsion between the atoms in the student's shoes and the atoms in the tile.
- (D) The weak nuclear force creating a force of repulsion between the leptons in the student's shoes and the nucleons in the tile.

2. A neutral baryon is comprised of three quarks: two down quarks which each have a charge of $-\frac{1}{3}e$, where e is the elementary charge, and an up quark. What is the charge on an up quark?

- (A) $+\frac{1}{3}e$
- (B) $-\frac{1}{3}e$
- (C) $+\frac{2}{3}e$
- (D) $-\frac{2}{3}e$

3. Following a period of extended use, the battery-powered circuit at right no longer functions. What are reasonable explanations for the circuit no longer functioning? Select the two best answers.

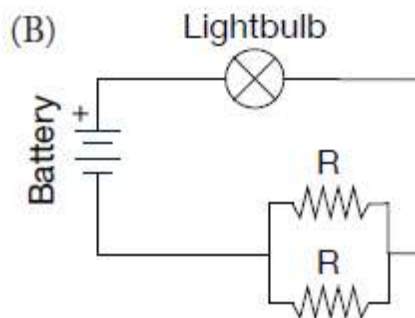
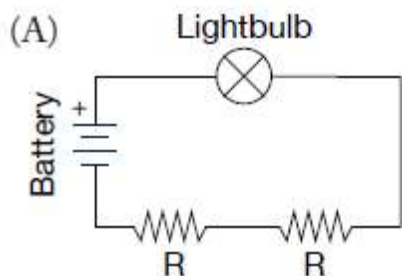
- (A) The electrons from the battery are used up as the circuit "runs out of juice."
- (B) The potential difference supplied by the battery has degraded.
- (C) The current in the circuit has been converted to heat in the resistors.
- (D) The battery can no longer supply sufficient power to operate the circuit.



4. The magnitude of the force of attraction between two point charges is F . If the magnitude of each point charge is doubled, and the distance between the charges is doubled, what is the new magnitude of the force of attraction between the point charges?

- (A) $F/2$
- (B) F
- (C) $2F$
- (D) $4F$

5. Consider two circuits, A & B, shown below. Both have identical resistors of resistance R and identical light bulbs.



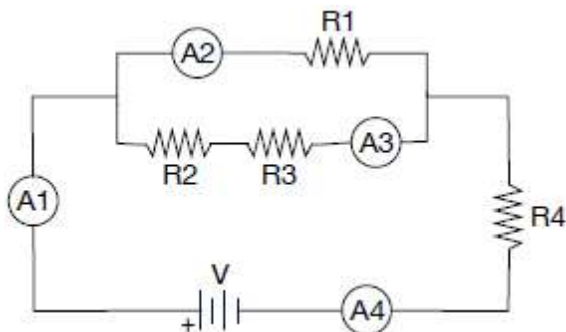
Correct statements about the bulbs in each circuit include which of the following? Choose 2 statements.

- (A) Bulb A and Bulb B are the same brightness because the resistances are all the same.
- (B) Bulb B has a greater voltage drop across it than Bulb A.
- (C) The currents through each bulb are the same as the currents through their respective batteries.
- (D) Bulb A has a greater current through it than Bulb B.

6. A scientist claims that she has captured and isolated a top quark and measured the magnitude of its charge as 5.33×10^{-20} C. Which of the following best explain why this claim should be doubted? Select two answers.

- (A) The magnitude of the charge on a top quark is two-thirds of an elementary charge, which is twice as large as the charge the scientist measured.
- (B) The smallest observed unit of charge that can be isolated is the elementary charge.
- (C) Particles cannot have a charge less than an elementary charge.
- (D) It is physically impossible to measure any charge smaller than an elementary charge.

7. The circuit schematic below shows four resistors and four ammeters connected to a voltage source, V. It is known that the current in ammeter A1 is 6.0 A, and the current in ammeter A2 is 2.0 A.

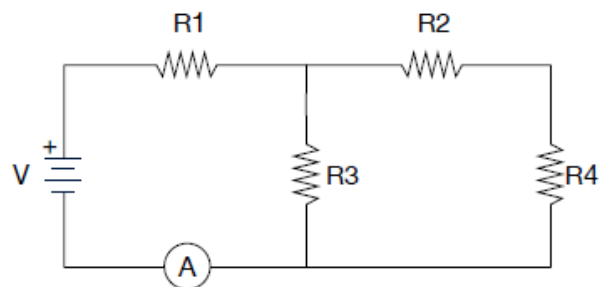


- I.** Which of the following must be true statements about the current through resistors R2 & R3?
- (A) The current through both must be 4.0 A because they have the same voltage drop across them
 - (B) The current through both must be 4.0 A because they are in series with each other
 - (C) The current through both must be 2.0 A because they share the current in the lower branch
 - (D) The current cannot be determined without information about the resistances of R2 & R3

II. If the resistance of R4 is given, what other information is necessary to determine the value of V, the voltage of the battery?

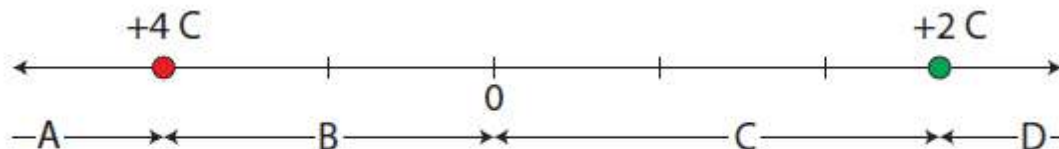
- (A) the reading of ammeter A4 and resistance of R2
- (B) the reading of ammeter A4 and resistance of R1
- (C) resistance of R1
- (D) resistances of R1, R2 & R3

8. In the circuit shown at right, resistors R1, R2, R3, and R4 all have the same value of resistance. Removing which resistor from the circuit would result in the smallest change to the ammeter reading? Select two answers.

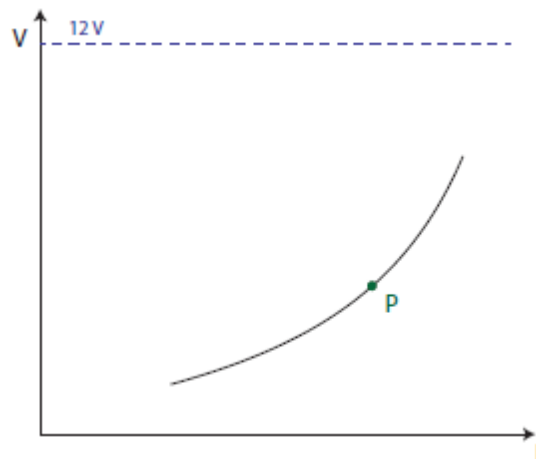


- (A) R1
- (B) R2
- (C) R3
- (D) R4

9. A +4 C point charge and a +2 C point charge are situated on an axis as shown in the diagram. In which region can you place an unknown point charge and have it remain at rest?



10. The graph at right shows a plot of voltage versus current for a filament lamp. The 12 V dashed line shows the voltage setting of the power source.

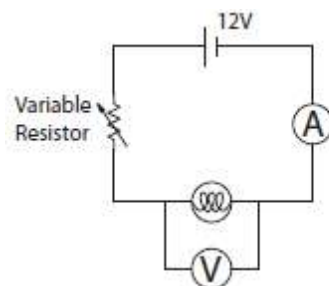


- (a) Explain how the graph shows that the filament *does not* obey Ohm's Law.
- (b) Give a physical explanation of why the filament lamp does not obey Ohm's Law.
- (c) Explain how one would determine the resistance of the filament for point P on the graph.

(d) In order to gather the data to make the graph shown above, a variable resistor was placed in series with the filament lamp, and both were connected to a 12-volt source as shown in the schematic to the right. →

Explain why using a variable resistor in series with the lamp

i. will not allow a reading of 0 V across the filament lamp.



ii. will not allow a reading of 12 V across the filament lamp.

11. The circuit at right shows a light bulb of resistance $2R$ connected to a battery with no internal resistance and two resistors, each with a resistance R .

(a) Which component has more current passing through it, the light bulb or either of the resistors? Give a detailed explanation with supporting equations if necessary.

(b) Develop an expression for the voltage drop across the light bulb as a fraction of the battery voltage, V . Give detailed support.

(c) Suppose one of the resistors, R is removed from the circuit, without reconnecting the wires. Which component will develop more power, the remaining resistor or the light bulb? Justify your answer.

